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SCIENCE

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SCIENCE

NEW YORK, JULY 8, 1892.

DIAMONDS IN METEORITES.

BY OLIVER WHIPPLE HUNTINGTON.

THE mineral cabinet of Harvard College received some time ago, through the liberality of Francis Bartlett, Esq., one of the two large masses of meteoric iron first brought by Dr. A. E. Foote from Arizona, and called by him the Cañon Diablo iron. This mass of iron, weighing 154 pounds, is in many ways unique, and chiefly so for the circumstance that it contains diamonds.

This fact was first made known by Professor G. A. Koenig of Philadelphia, who found in cutting one of the fragments that the cutting tool refused to penetrate the wall of a small cavity which it chanced to encounter, and this cavity was found to contain small black diamonds.[1] One white diamond of microscopic dimensions was said to have been found but subsequently lost, and no further account of this interesting occurrence appears to have been published.

In order to determine whether other portions of the Cañon Diablo iron contained diamonds, the author dissolved a mass of about one hundred grams weight in acid, assisted by a battery. The iron was supported on a perforated platinum cone hung in a platinum bowl filled with acid, and the cone was made the positive pole and the dish the negative pole of a Bunsen cell. When the iron had disappeared, there was left on the cone a large amount of a black slime. This was repeatedly washed and the heavier particles collected. This residue examined under a microscope showed black and white particles, the black particles being mainly soft amorphous carbon, while the composition of the white particles appeared less easy to determine, though when rubbed over a watch-glass certain grains readily scratched the surface.

The material was then digested over a steam-bath for many hours with strong hydrofluoric acid, and some of the white particles disappeared, showing them to have been silicious. Most of them, however, resisted the action of the acid. These last were carefully separated by hand, and appeared to the eye like a quantity of fine, white, beach sand, and under the microscope they were transparent and of a brilliant lustre. A single particle was then mounted in a point of metallic lead, and when drawn across a watch-crystal it gave out the familiar singing noise so characteristic of a glass-cutter's tool, and with the same result, namely, of actually cutting the glass completely through. To verify the phenomenon, successive particles were used for the purpose, and with the same result. The experiment was then tried on a topaz, and the same little mineral point was found to scratch topaz almost as readily as it did glass. It was finally applied to a polished sapphire, and readily scratched that also, proving beyond question that this residue of small, white, transparent grains must be diamond, though no well-formed crystals could be recognized.

It has long been known that carbon segregates from meteoric iron in the form of fine-grained graphite; and, when Haidinger found in the Arva iron a cubic form of graphite, it was suggested by Rose that the crystals might be pseudomorphs of graphite after diamond. More recently Fletcher described a cubic form of graphite from the Youngdegin meteorite, under the name of Cliftonite.[2]

Finally, a meteoric stone which was seen to fall at Nowo-Urei, in Russia, in 1886, was discovered two years later to contain one per cent of a carbonaceous material, which not only had the crystalline form of the diamond but also its hardness, so that, instead of being regarded as a pseudomorph after diamond, it was compared with the black diamonds of Brazil, called "carbonado."[3] And, lastly, in the Cañon Diablo iron we have true diamonds, though of minute dimensions. Thus it would appear that, under certain conditions, metallic iron is the matrix of the diamond.

Now, we further know that when cast iron is slowly cooled a considerable portion of the carbon separates in the condition of graphite. Moreover, the high specific gravity of the earth as a whole, as compared with the materials which compose its crust, give us ground for the theory that the interior of our planet may be a mass of molten iron. Therefore it would seem to be not an unreasonable hypothesis, that diamonds may have been separated from this molten metal during the formation of the earth's crust; and a support for this hypothesis may be found in the fact that at the Kimberley mines of South Africa diamonds occur in, what appear to be, volcanic vents, filled with the products of the decomposition of intrusive material thrown up from great depths.

The late Professor H. Carvill Lewis, in examining the materials from the greatest depths of the South African mines, came to the conclusion that the diamonds were formed by the action of the intrusive material on the carbonaceous shale there found, and on this ground predicted the discovery of diamonds in meteorites;[4] but it must be remembered that a similar geological phenomenon appears on a grand scale in Greenland, and no diamonds have as yet been found in the Greenland irons, though they have been so carefully studied by the late Professor J. Lawrence Smith and others.

It is difficult to conceive of any chemical reaction by which diamonds could be formed from the action of melted igneous rock on coal, and all attempts to prepare diamonds artificially by similar means have signally failed.

The writer would urge that the segregation of carbon from molten iron is a well-known phenomenon, and the association of diamonds with amorphous carbon in the meteorite from Arizona indicates that under certain conditions such a segregation may take the form of diamond. The chief of these conditions is doubtless the length of time attending the crystallization, though it may also be affected by pressure; and if the earth, as many believe, is simply a large iron meteorite covered with a crust, it seems perfectly possible that if we could go deep enough below the surface we should find diamonds in great abundance.

[1] American Journal of Science, Vol. XLII., November, 1891.

[2] Min. Mag., 7, 121, 1887.

[3] American Journal of Science, xxvi., p. 74.

[4] British Association, 1886, p. 667.
Ibid, 1887, p. 720.

THE NUMBER OF BROODS OF THE IMPORTED ELM-LEAF BEETLE.

BY C. V. RILEY.

At the meeting of the Entomological Club of the A.A.A.S. in Washington last autumn, Professor John B. Smith, it will be remembered, gave some interesting observations on this beetle, made at New Brunswick, N.J. As the somewhat astonishing result of his observations, he stated that there was but one annual generation, and that the beetles actually went into hibernating quarters early in August. Professor Smith's statements were so emphatic, and evidently based on such careful observations, that they could not very well be gainsaid, but as they conflicted with my observations on the species in the latitude of Washington, for which I have recorded two generations, and exceptionally a third, I was anxious the present season to go over the ground again, still more carefully than in the past, and, by rearing in confinement the first generation of larvæ from the first eggs hatched, to thus verify, in a manner which could leave no possible doubt, the facts which I had previously recorded.

In this brief note, I desire simply to state that at the present time (June 30) I have eggs laid by the second brood of beetles, i.e., the beetles obtained from larvæ which were feeding during the month of May and early part of June, thus proving, in the most positive manner, that in the latitude of Washington there are at least two broods, and that the second brood of larvæ will be feeding during July.

The following from the Appendix to the second edition of Bulletin 6, Division of Entomology, Department of Agriculture, October, 1891, will bear repeating in this connection:—

"One statement in the life-history of the Imported Elm-Leaf Beetle, as given in the preceding pages, may have to be corrected in the light of the observations of the past six years, and that is in reference to the number of annual generations. Like other leaf-beetles, this insect occupies an extended time in oviposition. The eggs appear to develop slowly in the ovaries, and a single female will deposit a number of the characteristic little yellow batches. This fact, taken in connection with the retardation of certain individuals of a generation, results in an inextricable confusion of broods. Adult beetles, pupæ, larvæ in all stages, and eggs, will be found upon trees at the same time, in Washington, during the months of June, July, August, and even later. From this fact it is almost impossible to estimate the number of annual generations without the most careful breeding-cage experiments. There is no evidence that the facts upon record are based upon such careful experiments. Glover, in the annual report of this department for 1867, page 62, says: 'After becoming pupæ, in a few days the skin of the back splits open and the perfect insect crawls forth, furnished with wings, by means of which it is enabled to fly to other trees and deposit its eggs, thus spreading the nuisance to every elm in the neighborhood; or it may ascend some tree and lay the eggs for a *second generation*, which destroys the second crop of leaves, frequently so enfeebling or exhausting the tree that it is unable to recover and eventually perishes.' Again, in the Annual Report for 1870, page 73, he says: 'The perfect beetles appear in a few days and immediately fly up into the tree to lay their eggs for a *second generation*, which frequently destroys every leaf on the tree.'

"The European records seem strangely silent upon this point. In the articles by Leinweber and Frauenfeld, referred to upon page 6, there is no indication of the number of generations, but it may be inferred that only one, namely, that of June and July, has been under observation. Heeger, however (*loc. cit.*, p. 114), says that 'under favorable circumstances there are three to four generations during the whole summer. Toward the end of August the insect ceases feeding and retires—partly as larvæ and partly as beetles—to winter rest under fallen leaves, in the cracks of bark, holes in the trunks of the trees, and in the ground itself.' This observation was made near Vienna.

"Our statement upon page 8 was a general one, based upon the observations in August. This state of affairs may probably hold in more northern regions, but in Washington it is safe to say that there are two generations, because, as just stated, newly developed beetles (the progeny of those which hibernate) appear in early June. These lay eggs, and, in fact, egg-laying may continue until the end of September, and larvæ have actually been found by Mr. Pergande in October."

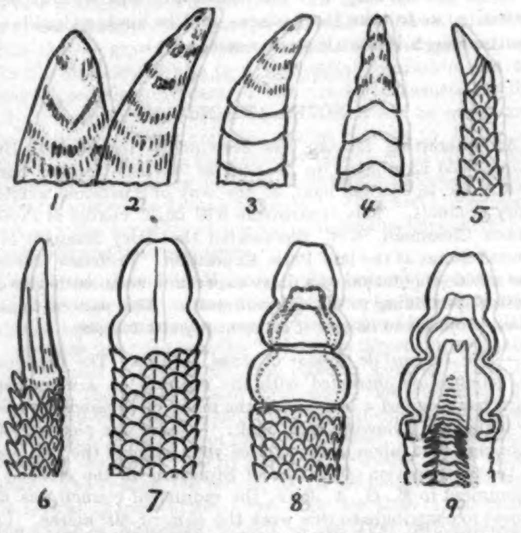
THE REPTILIAN RATTLE.

BY S. GARMAN.

Among the specimens secured by Dr. Georg Baur, in his explorations of the Galapagos Islands, there are a number of large lizards of the genera Conolophus and Amblyrhynchus, which exhibit certain peculiarities in the spines of the dorsal crest. Externally each of the spines resembles the rattle of a small rattlesnake. The likeness was evidently brought about by causes similar to those through which the rattle was originated. In a measure, these spines confirm my statement of the evolution of that organ as published in 1888 (Bull. Mus. Comp. Zool., viii., 259). Figures 1–4, herewith, represent a couple of the nuchal spines in a lateral aspect and views, side and front, of one of the dorsal spines of the Galapagos lizard, Conolophus subcristatus. On making a longitudinal section of any of these spines they are seen to be wholly dermal and to contain neither bones nor muscles. Their epiderm is a little thicker than that of the scales on the flanks. It is apparent that for a time, after hatching, growth of the skin was rapid and regular. The spines developed during this period were subpyramidal; they tapered so much, on back as on neck, that the slough came off readily and was lost. A periodic growth was taken on in later stages, and, the spines having become more elongate, a slight constriction was formed around the base, from folding the skin by bending the spine from side to side. Becoming still more elongate, the foldings meanwhile increasing in extent and depth, a stage was finally reached which, mayhap aided by shrinkage, retained the epiderm of the spine in place as a cap after the general slough was cast. Thus one thickness after another was added to the covering of the spine, each of the older being shoved farther up, by growth, so as to expose below it a band of the newer cuticle. The folded lower edge, the collar, of the cap rested in a basal groove or furrow, and prevented displacement. Each cap was closely applied to that beneath it, and the spine as a whole was solid. Outwardly the spines resemble rattles; internally the caps rest one upon another too closely to rattle.

The tip of the tail of the common snake ends in a spine somewhat like that in the crest of the lizard. It differs in containing a bone, the end of the vertebral column. Sloughing is similar in the two cases, a slight variation only being induced on account of the included vertebra. On most snakes the spine tapers greatly, and the cap is carried off in

the slough. On a few there are constrictions and ridges around the cap, that recall those on the spines of the lizard. As it happens, those marked in this manner are the nearest living allies of the rattlesnakes. In the paper on the Evolution of the Rattle, above cited, the copperhead, Ancistrodon (Fig. 5), was brought forward as most nearly representing the ancestor of the smaller rattlesnakes, Sistrurus; and the bushmaster, Lachesis (Fig. 6), of northern South America, was suggested as the most likely for the large rattlers, Crotalus. These forms were pointed out as so nearly approximating a condition from which the possession of a rattle was a necessary consequence that we might at any time expect to find individuals on which the caps were mechanically retained. My conclusions in regard to the inception of the rattle seem to be indirectly confirmed by what obtains on the lizards. This will be the more apparent if it is borne in mind that the present development of the rattle (Figs. 7–9) embraces much that is a consequence of its



Figs. 1–3, nuchal spines, and 3–4, a dorsal spine of Conolophus subcristatus; Fig. 5, tail of Ancistrodon contortrix; Fig. 6, tail of Lachesis mutus; Fig. 7, Sistrurus catenatus, at birth; Figs. 8–9, Crotalus confluentus.

possession, much that has been induced by its presence and use. The greater part of the shortening-forward in the extremity of the tail, of the compacting and consolidation of the posterior vertebræ, with the enlargement of the cap to include them, and much of the development of the caudal muscles must be eliminated before one can realize the primary condition of the rattle, a condition which was, no doubt, but a little advanced upon that now existing in Ancistrodon and Lachesis, as sketched in Figs. 5 and 6.

Mus. Comp. Zool., Cambridge, Mass.

OPPOSITION OF MARS.

BY EDGAR L. LARKIN.

THE coming opposition of Mars will be of interest to astronomers throughout the world; and extensive preparations are being made to observe it. The face of the god of war is sure to be watched, drawn, and photographed with more care than ever before. And the most perfect spectroscopes made will be turned on his ruddy disk. The sun, earth, and Mars will be on the same straight line nearly, on Aug. 3 at 13 h. 13 m., or at 1 h. 13 m. A.M., Aug. 4, 1892. The time of the opposition will be favorable for observation, since the earth passes its aphelion on July 1, while Mars does not pass his perihelion until Sept, 7. That is, the earth will be 34 days only past the time when at its greatest distance from the sun; and Mars but 35 days from its nearest approach. If these dates could coincide — opposition take place when the earth is at a maximum and Mars at a minimum distance from the sun — then would the earth and Mars be at a minimum distance from each other, or 33,864,000 miles; in which computation a solar parallax of 8.8″ and a mean distance of Mars of 141,500,000 miles were employed. However, since the opposition will occur midway between, it is probable that, at the moment of the nearest approach of the two planets, they will be distant about 35,500,000 miles.

The last opposition favorable for close observation was on Sept. 5, 1877; at which approach, Professor Asaph Hall discovered two minute moons in revolution around our neighboring world. This important discovery is best given in Professor Hall's own language: "The sweep around the planet was repeated several times on the night of Aug. 11, and at half-past two o'clock I found a faint object on the following side and a little north of the planet, which afterwards proved to be the outer satellite. On Aug. 16 the object was found again on the following side of the planet. On Aug. 17, while watching for the outer satellite, I discovered the inner one." Perhaps this optical discovery reveals the power of modern telescopes in a manner more impressive than any other, thus: "The outer one was seen with the telescope at a distance from the earth of 7,000,000 times its diameter. The proportion would be that of a ball two inches in diameter viewed at a distance equal to that between the cities of Boston and New York" (Newcomb and Holden, "Astronomy," p. 338).

These moons were seen with the 26-inch glass at Washington; but now a 36-inch telescope is in waiting for Mars, and none can predict what will be discovered. The satellites are estimated to be 6 and 7 miles in diameter; and they have a most rapid motion. It is well to note some of the facts about these bodies that served a great purpose, in sweeping away that mythology of astronomy, the nebular hypothesis. Distances from centre of Mars: Deimos, 14,600 miles; Phobos, 5,800 miles. Times of revolution: Deimos, 30 h. 18 m.; Phobos, 7 h. 39 m. But it requires 24 h. 37 m. for Mars to turn on its axis, which divided by 7 h. 39 m. equals 3.22; that is, the inhabitants of Mars have 3.22 months of Phobos every day. This moon rises in the west and passes through a phase in 1 h. 55 m. Deimos is 130 h. 37 m. from rising to rising, or 65 h. 18 m. from rising to setting. Its gain over the rotation of Mars is 3° 24′ per hour, hence it requires 106 hours to gain a whole revolution, which, added to the diurnal rotation of the planet, gives the 130 h. 37 m. But 65 h. 18 m. equals 2.155 months of Deimos; therefore the other satellite passes more than two full sets of phases while above the martial horizon, with plenty of eclipses beside.

The main interest in the next opposition rests in the hope that an accurate map of Mars can be made, or that good photographs can be secured, or that the spectroscope may make further revelations concerning the absorption of solar rays by its atmosphere, or that the lines due to the vapor of water may be seen to better advantage, if possible, than at the last. Professor C. A. Young, "Astronomy," p. 337, says: "The probability is that its density is considerably less than that of our own atmosphere. Dr. Huggins has found with

the spectroscope unequivocal evidence of the presence of aqueous vapor."

The idea that water exists on Mars is supported by the fact that white patches are seen on the poles, and that these vary in size with variations of inclination of the axis toward the sun. The white area is now well seen at this observatory on one of the poles. So rapid has been the advance in celestial photography, and in spectroscopy, and also in the size of telescopic objectives during the last 15 years, that without doubt much additional knowledge of Mars will be gained in August.

Knox College Observatory, Galesburg, Ill., July 1.

CROSS-FERTILIZING AND HYBRIDIZING.

THE following excellent suggestions are from the eminent horticulturist, Professor T. J. Burrill, of the Illinois experiment station. The subject is one calling for the cooperation of farmers and fruit growers everywhere with the experiment stations, for where nature has laid the foundation for improvement by giving us such a wild seedling as the Concord grape, that should be made the basis for further work.

Cross-fertilizing and hybridizing have been carried on to some extent, both for the effects of crossing and for the purpose of producing, if possible, new varieties of value. A number of crosses have been made in the apple, as for instance, between Ben Davis and Grimes, Ben Davis and Minkler, or Ben Davis and Duchess, with a view of getting something that will bear like the Ben Davis, but have the better quality of Grimes or Minkler, having the keeping quality of Ben Davis and the hardiness of tree of the Duchess. Different varieties of strawberries have been crossed, and plants are growing from the crossed seed. Blackberry varieties have been crossed, seeds planted, and plants are growing. Raspberries have been crossed — black varieties together, red varieties together, black with red, and blackberries with raspberries. We have now ready for planting more than a quart of seed from crossed raspberry and blackberry, or from selected varieties.

Results are problematical, but there is certainly great room for improvement in our blackberries and raspberries. There is entirely too much seed for the amount of flesh. When we consider that our apples originated from a crab in no way superior to many of our own native wild crabs, and the excellence that has been developed by cultivation and selection, what may we not expect from our raspberries and blackberries, which are so much better naturally? We have only begun with the raspberry and blackberry group of plants. I believe none of the blackberries or dewberries now cultivated are the result of growing plants from seed, but that all are the result of propagating natural seedlings, and it is not at all certain that we have yet the best of the wild varieties. Most of our raspberries are the result of chance.

During the past three seasons some work has been done in the line of crossing and selecting corn. The results seem to indicate that corn grown from crossing two distinct varieties will be larger than the average of the kinds crossed, or where the parents are nearly equal in value. To be sure, nothing has yet been reported in that line, though there would seem to have been abundant time for seedlings to have been grown. If the results of our crosses in corn are to serve as an index, we might expect to find in a second or third generation fruit of the Vinifera type on vines of the Labrusca. There is a great difference in the susceptibility of fruits to the influence of man. Our grapes have had more time spent on them, extending over a longer period, than have our strawberries; yet the results from grapes are hardly to be compared with the results from strawberries.

A small start has been made in the growth of nuts. The attempts at improvement heretofore have been confined almost exclusively to the pecan and chestnut. Attempts at improvement by growing seedlings from the best native trees have usually been a disappointment, because the seedlings have been inferior to the tree from which seed was taken, just as 999 of every 1,000 seedlings grown from the Concord grape have been so inferior to the parent as to be unworthy of general distribution. But it must be remembered that while there are comparatively few chances for improvement by growing seedlings there are none from simply budding or grafting.

The filbert and walnut of Europe are too tender for our climate. Why may not our hazel-nut and walnut be improved so as to take their places, and be made valuable crops for the rough lands along our streams?

NOTES AND NEWS.

AN interesting feature has been added to the first United States Food Exhibition, to be held at Madison Square Garden, New York, in October next, in the way of a national exhibit of dairy products. This department will be in charge of Professor James Cheesman, who represented the dairy interests of the United States at the late Paris Exposition. Professor Cheesman has a wide reputation as a dairy expert and as an authority on all matters pertaining to the dairy interests. This part of the exposition promises to be one of its most popular features.

— The *Journal de Colmar* of June 19 says: The president of the committee entrusted with the erection of a monument to Hirn has received a letter from the maire of Strasburg, in which he makes the following statement: "I have the pleasure of announcing that, upon the receipt of your letter of the 23d, relative to the participation of the city of Strasburg in the erection of a monument to M. G. A. Hirn, the municipal council has determined to contribute to this work the sum of 800 marks. I have ordered this amount to be credited to you, and it may be obtained from the municipal collector, who will transfer it to the treasurer of the committee, M. Baer. I trust that the example of Strasburg will find many imitators."

— Cornell University closed the college year 1891-2 on June 16, conferring above 300 degrees, of which about one-half were in scientific and technical courses, and a large number of which were the higher degrees. The graduating class was the largest in the history of the University, and is said to have been the strongest. The year terminates the connection of a number of the members of the faculty with the university, and this fact and the anticipated growth for the coming year will render it necessary to appoint a still larger number of new professors and instructors. The indications, judging from the numbers entering at the June examinations, are said to point to an entering class in September of not far from 500, and of probably fifteen or twenty per cent more in the upper classes and as graduate students, making a probable total of about 1,600 in all departments and classes. Sibley College, with its special and graduate schools and departments in mechanical engineering, will prepare for a total of 625 students, a hundred more than in 1891-2. In addition to new appointments already made, it is expected that professorships will be filled in geology, chemistry, and possibly one or two other subjects; also a number of assistant professorships and many instructorships in all departments, including physics, engineering, and mechanic arts. The appointments in scientific departments are usually such as demand familiarity with laboratory instruction, especially in electricity and mechanics.

— A Geographical Exhibition, we learn from the Proceedings of the Royal Geographical Society, will be opened this summer at Moscow, in connection with the two International Congresses of Prehistoric Archæology and Anthropology, which are to be held in the ancient Russian capital. The General Staff will exhibit a collection of all the maps, descriptions, and surveys made by Russian travellers in Central Asia, China, and Korea, which are deposited in the Topographical Department of the General Staff and the Scientific Military Committee. They will show also the recently-published maps, based upon surveys in the Empire and adjacent countries. A catalogue of these works is now in preparation.

— The degree of M.A. was conferred, *honoris causa*, upon Professor Edward Sylvester Morse at the recent Harvard commencement. Professor Morse was born in Portland, Me., in 1838. When but thirteen years of age he began to form a collection of minerals and shells. His first occupation was as a mechanical draughtsman at the Portland locomotive works. Afterward he made drawings on wood for a Boston concern. In 1852 he began a course of study under Agassiz at the Museum of Comparative Zoology in Cambridge. In 1866 he founded the *American Naturalist*, now published in Philadelphia. In 1868 he was made a fellow of the American Academy of Arts and Sciences. In 1871 Bowdoin College gave him the degree of doctor of philosophy. In 1874 Harvard elected him to a university lectureship, and he was also chosen vice-president of the American Association for the Advancement of Science, of which association he afterward became president. While studying marine zoology in Japan he accepted a professorship in the Imperial University at Tokio. He made several other visits to Japan, and formed a collection which was recently sold to the Boston Museum of Fine Arts. Professor Morse is also the inventor of numerous ingenious appliances for both scientific and domestic uses.

— The British consul in Hainan, in his last report, says, according to *Nature*, that during the past year he has made two journeys in that island, one to certain prominent hills near Hoihow, known as the "Hummocks," which lie fifteen miles to the west, on the road to Ch'eng-mai, the other a gunboat cruise to Hansui Bay. The people at both these places, and presumably all along the north-west coast, though believing themselves Chinese, speak a language which is not only not Chinese, but has a large percentage of the words exactly similar to Siamese, Shan, Laos, or Muong. The type of the people, too, is decidedly Shan, without the typical Chinese almond eye. At one time (1,000 years ago) the Ai-lau or Nan-chau Empire of the Thai race extended from Yun-nan to the sea, and the modern Muongs of Tonquin, like the Shans of the Kwangsi province, the ancestors of both of which tribes belonged to that empire, probably sent colonies over to Hainan; or the Chinese generals may have sent prisoners of war over. It is certain that some, at least, of the unlettered, but by no means uncivilized, tribes in the central parts of Hainan speak a type of language which is totally different from that spoken by the Shan-speaking tribes of the north-west coast. Yet the Chinese indiscriminately call all the non-Chinese Hainan dialects the Li language. The subject, Mr. Parker says, is one of great interest, well worth the attention of travellers. It was his intention to pursue the inquiry when making a commercial tour of inspection round the island, but his transfer to another post compels him to abandon his scheme.

— The latest researches of the Finnish expedition to the Kola Peninsula will modify, as we learn from *Nature*, the position of the line which now represents on our maps the northern limits of tree-vegetation in that part of Northern Europe. The northern limit of coniferous forests follows a sinuous line which crosses the peninsula from the north-west to the south east. But it now appears that birch penetrates much farther north than the coniferous trees, and that birch forests or groves may be considered as constituting a separate outer zone which fringes the former. The northern limits of birch groves are represented by a very broken line, as they penetrate most of the valleys, almost down to the sea-shore; so that the tundras not only occupy but a narrow space along the sea-coast, but they are also broken by the extensions of birch forests down the valleys. As to the tundras which have been shown of late in the interior of the peninsula, and have been marked on Drude's map in Berghaus's atlas, the Finnish explorers remark that the treeless spaces on the Ponoi are not tundras but extensive marshes, the vegetation of which belongs to the forest region. The Arctic or tundra vegetation is thus limited to a narrow and irregular zone along the coast, and to a few elevated points in the interior of the peninsula, like the Khibin tundras, or the Luyavrurt (1,120 metres high). The conifer forests, whose northern limit offers much fewer sinuosities than the northern limit of birch-growths, consist of fir and Scotch fir; sometimes the former and sometimes the latter extending up to the northern border of the coniferous zone.

— A sealed bottle containing a paper requesting the finder to report the place and date of discovery was thrown into the sea at Coatham Pier, Redcar, by Mr. T. M. Follow, on Oct. 8, 1891. On April 12, 1892, according to the Proceedings of the Royal Geographical Society, the bottle was picked up by a fisherman off the island of Hjelmesö, in the extreme north of Norway. The bottle had been immersed for six months, and the shortest distance between the two points is 1,400 miles. This observation confirms the general set of the currents from the east coast of Britain, at first south-easterly and then northerly along the continental coast, as shown in Mohn's map of surface drift in the North Sea and Norwegian Sea in Petermann's "Ergänzungsheft," No. 79, for 1885.

— The Russian *Official Messenger* (April 22) announces that the Ministry of Domains has decided to make, next summer, the following explorations in Caucasia: (1) The exploration of the mineral springs of the Eastern Caucasus having now been completed, to carry out a similar work in Central and West Transcaucasia; namely, the mineral waters of Khvedur, Uravel, Tsikuban, Platen, and others, in the governments of Tiflis and Kutais, and in the Chernomorsk District; (2) to continue the systematic geological exploration of the government of Tiflis, especially of the valleys of the Yora and the Alazan in Kahetia, and their mineral resources, in view of the projected construction of a railway in Kahetia; and (3) as the detailed study of the Apsheron naphtha region was terminated last year, and the map of the region is ready, to complete the exploration of the Caspian coast naphtha region, and to explore the nickel ores of Daghestan. The geologist, Simonovich, and the mining officers, Konshin, Barbot-de-Marny, and Gavriloff, are commissioned for this purpose, while M. Rughevich is commissioned to explore the naphtha region along the new Petrovsk branch of the Vladikavkaz Railway, which yielded last year 15,000 tons of naphtha, and promises to become an important centre of naphtha industry.

— Professor Elihu Thomson, the inventor of the Thomson-Houston Electric Company, contributes an entertaining, scientific, and thoughtful paper on "Future Electrical Development," to the July *New England Magazine*. He explains the possibilities of electricity, in all the public and private conveniences of life, and gives practical examples of its application to manufactures, rapid transit, and domestic offices, such as cooking, ironing, heating, gardening, raising fruit and vegetables, etc.

— Macmillan & Co. announce the issue of a new and extensively revised edition of Mr. Bryce's "American Commonwealth." It is to be expected that this new edition will take notice of the many important changes which have occurred since the work was first issued. It is to be copyrighted in America. The same publishers have already issued more than half of Stephen's "Dictionary of Biography," one volume of which is published quarterly. Thirty out of a total of fifty volumes have appeared so far, and the enterprise is so well in hand that there will be no break in the publication of the remaining parts. The work when completed will contain at least thirty thousand articles by writers of acknowledged eminence in their several departments. The memoirs are the result of personal research, and much information has been obtained from sources that have not before been utilized. It has been the aim of the editors to omit nothing of importance and to supply full, accurate, and concise biographies, excluding, of course, those of persons still living.

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ON THE UNCERTAINTY OF CONCLUSIONS.[1]

BY T. C. MENDENHALL.

ABOUT seven years ago, on the morning of a cold day in winter, a rough-looking, scantily-dressed man was observed to leave a freight car, which was standing upon a side-track near a small country town, and make his way rapidly into the fields and woods beyond.

From his appearance it was evident that he belonged to that vast army of tramps which is never in need of mobilization and which carries upon its muster-rolls many who possess most of the virtues of the good and none of the vices of the bad, having lost only the power of further resistance against continued antagonism and unfriendly environment.

The behavior of this man excited no comment, and his existence was remembered a few hours later only because of the discovery of the body of a stranger, who had evidently been murdered, on the floor of the car which he had been seen to leave. Pursuit followed immediately, and capture within a day or two. One or two clever detectives interested themselves in finding evidence of his guilt, and within a few days had prepared a case which lacked little in the detail of its elaboration or in its artistic finish.

It was proved that two strangers were seen in the suburbs of the town at a late hour on the previous night, although they were not together. The prisoner was identified beyond doubt as the man who hastily left the car in the morning. The murderer had left no means of identification except a small piece of muslin, evidently torn from the sleeve of his shirt, and which was stained with the blood of his victim. On the arrest of the prisoner one or two blood stains were found upon his clothing, and, what was more convincing than all else, the bit of sleeve found in the car fitted exactly into the place in his own garment, from which it must have been torn in the struggle which preceded the crime.

[1] Address as retiring president, delivered Jan. 20, 1892, before the Philosophical Society of Washington.

While all of this evidence might be classified as "circumstantial," it was so complete and satisfactory that no jury could be expected to entertain serious doubt as to the guilt of the prisoner, and, in spite of his protestations of innocence, a sentence to life imprisonment was in accord with the judgment of the general public.

Only a few weeks since this man was set free and declared to be innocent of the crime for which he had already served seven years at hard labor, the misleading character of the evidence on which he was convicted having been exposed through the voluntary confession of the real criminal. The facts thus brought out were, briefly, as follows: —

There were three men in the case. The first, who was afterward murdered, slept upon the floor of the car when the second, the real murderer, entered it. In the dark he stumbled over the sleeping man, who awoke and immediately attacked him. The quarrel did not last long, the original occupant being left dead upon the floor of the car while the murderer quickly made his escape, leaving the village and neighborhood behind him as far and as fast as possible. An hour or two later the third man, seeking shelter and sleep, finds his way into the car, and dropping on the floor, is soon in a deep slumber. He awakes at break of day to find that a dead man has been his companion, and to see that his own sleeve is smeared with the blood of the victim. Alarmed by this discovery, and realizing in some degree the perilous position in which he is thus placed, he tears off the stained portion of his garment, and, hastily leaving the car, he flees from the scene as rapidly as possible.

Nothing can be more simple or more satisfactory than this account of the affair, and yet nothing is more natural than that he should be accused of the crime and brought to trial. The evidence against him was convincing, and it was all absolutely true. It was not strange, therefore, that his conviction and imprisonment should follow.

It will doubtless appear to many that the foregoing is too closely allied to the sensational to serve fitly as an introduction to an address prepared for a society of philosophers, and I am ready to acknowledge the apparent validity of the criticism. I am led to its selection, however, because it is an account of an actual occurrence, which illustrates in a manner not to be misunderstood a not unrecognized proposition to a brief exposition and partial development of which I ask your attention this evening. This proposition is that, in the treatment of many questions with which we are confronted in this world, our premises may be absolutely true and our logical processes apparently unassailable and yet our conclusions very much in error.

No department of human knowledge or region of mental activity will fail to yield ample illustration and proof of this proposition. An astonishingly large number of debatable questions present themselves to the human intellect. Many of them are conceded to be of such a nature that differences of opinion concerning them must continue, perhaps, indefinitely.

But there is a very large and a very important class of problems, the solution of which is apparently not impossible and often seemingly easy, regarding which the most diverse views are most persistently held by persons not differing greatly in intelligence or intellectual training.

Men whose business it is to weigh evidence and to reach correct conclusions, in spite of inadequacy of information and perversion of logic, constitute no exception to this statement, but, on the contrary, furnish many of its most notable illustrations.

Many of the questions which present themselves to our jurists and juries are simply questions of fact, and the testimony on which the determination of such questions depends often comes from persons who are neither interested nor dishonest. In such cases it ought to be easy to reach a true conclusion, but there is often failure, growing out of honest differences of opinion.

An eminent attorney not long since referred in conversation to a certain decision of the Supreme Court of the United States concerning which there had been a strong dissenting minority. The question was one which involved neither passion nor politics, and he declared that to him it seemed utterly impossible for a disciplined mind to reach other than one conclusion regarding it.

In any review of this subject, such as is here suggested, it is neither necessary nor proper to refer to the numerous instances of utter failure in our judicial system, attributable to a lack of integrity on the part of those who administer the laws or to the mischievous results of appeals to passion or prejudice by unprincipled advocates. It is sufficient to recognize the fact that failure in the administration of law is not uncommon where witnesses are honest, juries intelligent and well-meaning, and judges incorruptible.

The rapidly increasing number of controversies within the church, to say nothing of those in which the disputants are on opposite sides of the wall, show conclusively that the logic of the theologian must sometimes go at a limping gait. In political or social economy there is great diversity of opinion among good and able men. Certain financial legislation by Congress is honestly thought by many people to be necessary to prevent widespread disaster and the financial ruin of one of the largest and most important classes of our citizens; by other equally intelligent and equally honest men such action on the part of the National Legislature is condemned as dishonest in principle and sure to be fatal to the business interests of the country.

A large number of able and patriotic men address themselves to the solution of the problem of the adjustment of duties upon imported merchandise. All have access to the same store of experience; the discussions and investigations of the past are open to all alike. In the end, however, their conclusions, even as to elementary principles, are diametrically opposed to each other.

But I have neither the time nor the disposition to enter into an exhaustive examination into the miscarriage of logic in the regions of politics, religion, or social science. I must restrict myself to some consideration of the uncertainty of conclusions reached by what may be broadly included under the general term "the exact sciences," a division of the subject not unlikely, I hope, to be of some interest to members of this society.

At the threshold of the investigation we are confronted by the term "exact sciences," and it is of the utmost importance to reach a clear understanding of the meaning of this phrase, in the beginning. By some writers its application is limited to the mathematical sciences or substantially to pure mathematics. This does not seem, however, to be in accord with the general usage among scientific men, and a wider significance will be here given to it.

Pure mathematics may, and possibly must, be regarded as a mode of thought; as symbolic logic; as an abridgment of mental processes by the selection of that which is common to all, and its formal expression by means of signs and symbols. Intellectual operations which, on account of their complexity and length, would be possible only to a few of the highest capacity are by the aid of mathematics brought within the range of the many. In virtue of the simple and beautiful nomenclature of the science, one can see at a glance, in a formula or equation, the various relations, primary and secondary, direct and implied, which exist among the several magnitudes involved, which, if expressed or defined in ordinary language, would be beyond the understanding of most intelligent people.

The principles and rules governing mathematical operations have been, in the main, so well worked out and so universally agreed upon that in mathematics one can hardly go astray, at least not without the certainty of almost immediate detection and conviction at the hands of many skilled in the use of this wonderful intellectual device. When dealing with quantity in the abstract, or with matter under just such restrictions or possessed of just such properties as are prescribed, mathematics becomes a machine of certain performance, the output of which can only be in error through the conscious or unconscious mistakes of the operator. As such it challenges the admiration of all, and it must forever be regarded as among the first, if not, indeed, the very first, of the few really splendid creations of the human intellect. When Plato, in reply to a question as to the occupation of the Deity, answered, "He geometrizes continually," he emphasized the dignity and the incontrovertibility of mathematical reasoning.

It is no reflection, then, upon the importance and value of the science of mathematics to leave it upon the pedestal which it rightfully occupies, considering it as separate and apart from other sciences. In their development it may and does play a most important part, in which, however, it is identified rather with the investigator than with the subject investigated; for, in studying the elementary principles of abstract dynamics, one may follow the now somewhat antiquated and cumbersome processes of Newton or the more simple and elegant methods of Clifford or Maxwell, but the results will in all cases be the same.

Before finally dismissing the pure mathematics, however, especial attention must be invited to one or two principles involved in their application by way of contrast with the condition of things which exists in the domain of the other sciences. It is sometimes declared by way of a criticism of mathematics that "what comes out of it is never better than what goes in." In a certain narrow sense this is true, but in a broader and truer sense it is as false as it would be to say that grain and fruit are no better than the soil from which they spring.

The mathematician has the great advantage over the physicist, the chemist, or the geologist that he not only can, but almost necessarily must, completely define the elements with which he has to deal. If he deals with matter, before he can put it into his equations he must needs restrict it as to form and dimensions and endow it with definite physical properties, the relations of which are capable of analytical expression. If, after this, his power of analysis is sufficiently great, the conclusions which he reaches can have no element of uncertainty in them, provided always they are considered as referring only to the supposititious material with which the investigation was begun. That the conclusions are not in harmony with known phenomena is evidence only of the fact that the material of nature is not the material which is symbolized in the formula, and that certain properties which are common to both are modified in the former by the presence of others which are not attributed to the latter. When MacCullagh, Neuman, Stokes, Sir William Thomson, or Max-

well, each evolves a dynamical or mechanical theory of light, a lack of agreement among them or with known principles of optics can generally be traced to the fact that the medium in which they suppose the action to take place has not been endowed with the same common properties by all, and that in every case it falls short of an exact representation of the real ether itself. With this important restriction upon mathematical reasoning kept continually in mind, mathematics may be safely set aside as the "one science of precision."

What, now, are the characteristics of the so-called "exact sciences" other than pure mathematics? Without attempting a rigorous definition or a precise classification, it is sufficient for the purpose at hand to declare that the exact sciences are those whose conclusions are capable of being, and for the most part are, established by experiment and verified prediction.

Among these exact sciences the most notable, in degree of exactness, is the science of astronomy. Although the conclusions reached in the study of astronomy may not in general be established by experiment, the marvellous accuracy with which its predictions are verified has long ago placed it far in advance of other sciences. An inquiry into the cause of this excellence will not show that the logic of the astronomer is any more rigorous than that of many others engaged in scientific research, but rather that the premises on which he reasons are simpler, and, what is of greater importance, more nearly sufficient. Until a very recent period in its history, astronomy, although dealing with matter, has been concerned almost entirely with only one of its many properties. The one property thus far assumed to be common to all matter is that long-known but still mysterious attraction in virtue of which there exists a stress between every particle and every other particle in the universe, according to a law the discovery and exposition of which justly entitles Newton to be considered the greatest philosopher of all ages. It happens that the hundreds and possibly thousands of other properties possessed by, or inherent in, matter have little if any influence on the dynamics of masses widely separated from each other, and therefore a knowledge of the law of gravitation seems to be sufficient to enable the astronomer, having, of course, obtained the necessary data from observation, to trace the paths of the planets and to foretell the configuration of the heavens many years in advance. Within the past twenty-five years, however, the splendid discovery of spectroscopy, aided by great improvements in photography, has given rise to a new astronomy, known as physical, as distinguished from gravitational astronomy. The new science deals with a matter of many properties, some of which are but little understood. While its conclusions are of vital importance and of intense interest, they result from deductions in which the premises are insufficient and are proportionately uncertain. The new astronomy must for a long time abound in contradictions and controversies, until, and largely through its development, we shall possess a knowledge of the properties of matter when subjected to conditions differing enormously from those with which we are now quite familiar. Because one astronomer declares that the temperature of the sun is 20,000° F., and another, equally honest and capable, says it is not less than 20,000,000° F., it must not be inferred, and it never is, except by the superficial, that the whole science of solar energy is a tissue of falsehoods, and that those engaged in its development are deliberately planning an imposition upon the general public. Even such widely varying results as these may be based on observations that are entirely correct and experiments that are beyond criticism. The discussion of the results obtained by observation and experiment may follow, in both cases, the very best models, and yet the conclusions may be erroneous and contradictory, owing to the insufficiency of data in the beginning.

Unfortunately the omission of one or more important quantities from the equations of condition is not always known or suspected. The older, more exact astronomy is occasionally caught tripping in this way. An interesting example of recent occurrence is to be found in certain observations for stellar parallax made a few years ago by members of our own society. The observations were long continued, the instruments used were of a high character, and the observers were skilful. These conditions unquestionably promise success. It was something of a surprise, therefore, when a reduction of the observations gave for the parallax a negative result. As such a result could in no way be possible, except, perhaps, through the assistance and intervention of a curvature in space (in virtue of which if a man's vision was not limited he would, by looking straight forward, see the back of his own head), it was assumed that the work was not as well done as it seemed to be, or that some imperfection in the instrumental appliances had been overlooked. It now appears, however, that this record may be reopened, and that the results may prove to be of as great value as originally anticipated. Researches carried on during the past year or two have with little doubt established the fact that the latitude of a point on the earth's surface is not a fixed quantity, but that on the contrary it varies through a small range during a period somewhat greater than a year. It is believed that if this hitherto unsuspected variation be applied to the parallax observations, referred to above, the seeming absurdity of the result will vanish.

If astronomy, the foremost of the exact sciences, is not free from the fault of basing conclusions upon insufficient premises, it will not be expected that among other sciences the evil will be of less magnitude.

When we consider the sciences of heat, light, electricity, magnetism, and other specially investigated properties of matter, all of which are usually included under the general head of "Physics," we meet with a formidable rival of astronomy in the extent to which they are entitled to be considered as exact sciences.

Physics treats of all the properties of matter, not omitting that which is the special domain of astronomy. As if this were not enough, the demands upon the science are such that it must also deal with that which is not matter, or, at least, is not matter in the ordinarily accepted sense. Although physics deals with all of the properties of matter, no physicist knows them, or, possibly, half of them. Perhaps not one of them is entirely and completely known. It would seem, therefore, that this science must of necessity be one of uncertain conclusions. That it is far from deserving so sweeping a criticism is due to the fact that the properties of matter are not so closely interrelated as to make it impossible to isolate one or more of them in experiment, and thus the problem is vastly simplified. It is probably impossible to do this rigorously in any case, so that there must always remain a small residuum of uncertainty due to the interference of unknown or imperfectly understood properties of matter.

Thus it is possible to treat a mass of matter as though it possessed mass only, ignoring its electrical, magnetic, or optical properties, its relation to heat, its elasticity, and other

physical characteristics, and investigate its behavior under the law of gravitation alone; its optical properties may be found to be nearly independent of its relation to heat, electricity, magnetism, etc., and so, in turn, each characteristic may be studied alone and equations obtained in which the number of constants is comparatively small. It is only after this plan has been pretty thoroughly worked out that it becomes possible to investigate the interrelations of these various properties, which are often obscure and difficult of detection. Their discovery, however, especially one or two great generalizations pertaining to them, such as that of the conservation of energy, must be regarded as the grandest triumph of physical science.

The science of physics is that which is most drawn upon in the formation of the so-called applied sciences. Wedded to mathematics as it is (and no amount of personal abuse on either side can ever furnish good reason for divorce), it becomes the mother of engineering in all of its various forms. Through and by it, the forces of nature have been directed, the elements have been subdued and some of them overcome, and man has made himself master of the world. Its marvellous progress has, therefore, been observed by the people, and is understood by them perhaps to a greater degree than that of any other science. The most eloquent orators and the ablest writers have employed their genius in sounding its praises.

It is not too much to say that when intelligent people speak, in a general way, of the wonderful things which science has accomplished during the past half-century, they have in mind, for the most part, the applications which have been made of discoveries in physical science. I think no one can justly question the assertion that of the several causes which have produced the splendid advances in the material interests of the whole world during the nineteenth century, science has contributed far more liberally than all others. So remarkable have been her achievements that all the people have come to look upon her as being nearly, if not quite, infallible. A reputation of which the votaries of science may be proud has been established, but, at the same time, one difficult to maintain. Here, as elsewhere, it is a good name only that is worth counterfeiting. It is quite worth the while of one devoted to the interests of pure science alone to occasionally inquire whether an impure article is not being placed upon the market. However indifferent he may be to the welfare of the general public, his own selfish instincts should incline him to such a course. He cannot clear his own skirts by declaring that the public deserves to be humbugged if it permits itself to be, for in this, as in everything else, the counterfeit when successful is not readily detected, and it is often made to appear more attractive than the genuine article.

In respect to this matter physical science presents two aspects. In a large degree it is a science of certain conclusions, and any false deduction is readily exposed by means of the many severe tests to which it may be subjected. On the other hand, in some of its branches it has not yet been found possible to isolate the elements which form a rather complex whole, and it therefore remains an observational rather than an experimental science. In the latter aspect it becomes comparatively easy prey for charlatans and well-meaning but ignorant non-professionals.

In no department of physical science is this better illustrated than in meteorology, the oldest and most abused of all sciences. From its early days, when weather forecasts were expressed in simple rhyme, to the present, when they are issued in a prose which in its scope and richness of vocabulary sometimes excites our highest admiration, meteorology has been a favorite victim of pretenders, conscious and unconscious. For years the people, after having first believed in, have patiently borne with, the predictors of disaster in the form of abnormal meteorological disturbances. They have suffered great mental distress, and they have lost enormous sums of money on account of floods, tidal waves, and earthquakes which never came, rains that never fell, and winds that never blew. They were becoming accustomed to this sort of thing, and were beginning to understand the spirit which guided the real meteorologists as manifested in the efforts of the great weather bureaus of the world, our own among the first, to foretell with a good degree of certainty what might happen within the next twenty or thirty hours. But not many months ago they were again brought to a high pitch of meteorological excitement by the somewhat sudden and certainly unexpected appearance of the "Cloud-compelling Jove." He came not in the singular, but in the plural, and each of him brought the best and most scientific device for producing a rainfall whenever and wherever a sufficient thirst was found to exist. The history of this new industry cannot yet be written. It is still in its infancy. The fallacy of its methods has already been commented upon in a public journal, by a distinguished member of our own society, but a few remarks upon its somewhat meteoric career during the past season will not be out of place in connection with the subject now under consideration.

The columns of the daily press reflected the general interest which was felt in the matter, especially in parts of the country where rainfall was greatly needed. As is always the case under such circumstances, the strong and entirely natural desire that its artificial production might be accomplished was soon converted into a belief that it had been, and a readiness to accept the flimsiest sort of evidence of relation between the means employed and the end sought. This confidence materialized, or better, perhaps, was taken advantage of in the formation of an "Interstate Artificial Rain Company, Limited" (I am quoting from the daily papers of Nov. 10, 1891), which, after the manner of its kind, was apparently organized not for the purpose of actually producing rain, but for the formation of other joint-stock companies ready to purchase the secret method of doing it. An alleged experiment, on which a business transaction was based, is thus described: —

"The party arrived in the city on Sunday, Nov. 1, and commenced operations on Sunday evening in a small outhouse on the edge of town. The conditions were extremely unfavorable for rain. No results could be seen at first, but on Friday the sky became overcast with clouds. On Saturday a high south wind prevailed, and on Saturday night some rain came from the south-west. On Sunday rain fell all day, and at night a norther arose. Reports from 100 to 150 miles around this town show that rain fell on Sunday in most localities in considerable quantities." So convincing was this to the buying company that the secret process was purchased by them for the sum of $50,000, "after which," the account rather unnecessarily adds, the selling company "left for home." But a business so profitable as this was not to be long without competition, and a few weeks later a telegram is sent to the leading newspapers of the country, announcing that a professor in a western State (it is pleasant to note that most of these public benefactors are "professors") is prepared to furnish rain more promptly and at less cost

than the genius whose machinery and methods have invited public approval. Proposals to do the county sprinkling at so much per acre are invited and offered, and at one time it seemed as if the whole business would be ruined by overproduction.

One of the most interesting phases of this subject was the attitude in reference to it assumed by a large part, possibly the greater part, of the intelligent public. It was one of expectancy and limited confidence. "Why not?" was commonly asked. "Look at what science has done within the last twenty-five years. Can anything be more astonishing? and is the artificial production of rainfall more difficult and more wonderful than many things which are now commonplace?" To many the logic of the experiments was convincing. After many battles rain had fallen, long lists of examples have been prepared, and hence it must be possible to produce rainfall by cannonading. If these views were entertained by a considerable number of intelligent people, and it is believed that they were, the situation is one which ought to be full of interest to men of science, involving, as it does, both a tribute and a warning.

It would be good for all if the intelligent public was in the habit of looking a little more below the surface of things. It is too much in the way of assuming that the president of the company engaged in exploiting an important invention or device is the genius who first discovered the principle in virtue of which it operates. It loses sight of — no, it does not lose sight of, because it never knew — the patient toil, the unselfish devotion, and, what is perhaps more important, the unflinching honesty with which a few men of the highest intellectual capacity have from the earliest times given themselves to the study of the laws of nature.

It would surprise the public to know how long ago and by whom many of the most recent and most brilliant applications of science were made possible. Would it not be in the interest of all if men of science were more ready and willing to take the intelligent public into their confidence; and would not the public, if familiar with the history of scientific investigation and accustomed to scientific modes of thought and criticism, be less the prey of charlatans and well-meaning but ill-informed enthusiasts? A better knowledge on both sides would lead to a better appreciation of both sides, and the real worker in science would seldom go without that public recognition which has too often been denied to the ablest men. No better illustration of this can be found than in the life of the distinguished first president of this society, to stand in whose place must always be an honor to any man. With his great work as secretary of the Smithsonian Institution the public is fairly well acquainted, and it has not been backward in bestowing honors in recognition of that work. Unfortunately, comparatively few know of what must be regarded, I think, as his greater work, the original researches in which he was engaged, and in which he was so singularly successful, before he became identified with the institution to which he gave the greater part of his life. Scant justice has yet been done to this important part of a career which must always be an inspiration to members of this society.

But I am warned that the brief time during which I can claim your attention to-night is quite insufficient for anything like a full exposition of the theme which I have selected, and I must, I fear, somewhat abruptly turn about in order that I may leave with you in somewhat more definite language one or two thoughts which I have attempted to develop by illustration and example.

Recurring to the unfortunate victim of circumstantial evidence, whose experience was related in the beginning, it will be admitted that the judge who charged, the jury who convicted, the witnesses who told the truth, and the approving public were all in error, in that they failed to recognize that there was another way of explaining what had happened. It does not necessarily follow that the explanation which explains is the true one. There are many natural phenomena which are in entire accord with more than one hypothesis. Indeed, there are some things which may be perfectly accounted for on an infinite number of suppositions, but it does not follow that all or any one of them must be accepted. There is nothing especially novel in this proposition, but I submit that to a failure to keep it in sight must be attributed a large measure of the uncertainty of the exact sciences, as well as much useless and bitter controversy in science, religion, ethics, and politics.

As a sort of corollary to this proposition I suggest that many reasoning and reasonable people are indifferent to, if not ignorant of, the fact that the value of evidence is greatly dependent on the way in which it arranges itself. To many this may be made a little clearer if I borrow a phrase from one of the most exact of modern sciences and speak of evidence as presenting itself in series or in parallel. Without pushing the analogy further, the superior strength of the latter arrangement will be evident upon reflection. On another occasion, I have referred at some length to the numerical representation of the value of testimony, and to some conclusions which are easily reached. As bearing upon the subject in hand, a single example of this method of treatment may be useful.

Let there be two witnesses, A and B. Suppose that A tells the truth 51 times out of 100; that is to say, assume that honesty holds the controlling share in his stock of moral principles. Let B be equally truthful and no more. Then if these two testify independently to the occurrence of a certain phenomenon it is more likely to have occurred than if either one alone bore witness. This is evidence in parallel. If, however, A testifies that B declares that the thing happened, it is less probable than if based on the testimony of either alone. This is evidence in series. Put as boldly as this, no one doubts the higher value of the first arrangement; but it is believed that a more careful consideration of this distinction will do much to secure a better judgment, not only where human testimony is involved, for here it has long been an established principle, but where conclusions are based on observation and experiment.

It is of the utmost importance, therefore, that men of science, before accepting a theory or a hypothesis as final, should carefully scrutinize the steps by which it has been established to see that they are not only sufficient but necessary. The true philosopher will be slow to claim that the theory which he finds sufficient to explain all of a given class of facts is the necessary and true one; he will be constantly on the lookout for a new fact which his theory will not quite explain, and he will have much consideration for his friendly competitor who finds a different hypothesis equally satisfactory and efficient. Above all, he will not pride himself on the steadfastness of his views, and will rarely bind himself to be of the same opinion this year as last.

If the general public could be made to understand the limitations by which science is circumscribed, the tentative and ever progressive character of scientific investigation, it would be good for the public and good for science.

The human race is greatly handicapped by the presence of a good number of people who strenuously object to being disturbed. During a decade, generation, or century these good but sometimes unpleasant people plant themselves along certain lines in the domain of science or politics or religion, proclaiming essentially that "here and here only is the truth, and here we fix ourselves forever." After awhile they somewhat unwillingly and with no very good grace move forward into a new position, again honestly affirming and believing that the end has been reached. A better knowledge and a broader human sympathy would reveal to them the hitherto unsuspected fact that truth may at the same time be here and there.

In the dissemination of this knowledge and the cultivation of this sympathy, science should lead, not follow. No scientific organization so young in years has done more along these lines, especially by reason of its extensive membership and the vigor and enthusiasm of its branches, than the society over whose deliberations during the past year I have been permitted to preside.

For the honor thus bestowed I beg now to make my formal and grateful acknowledgements.

REMARKS UPON THE GRAPHIC SYSTEM OF THE ANCIENT MAYAS.

BY HILBORNE T. CRESSON, A.M., M.D.

A MAYA hieroglyph may be a single character by which a meaning is expressed by the sound of the name of the thing represented, or it may have a number of components that convey by a similar method a series of ideas. The 'glyphs of *Kukuitz* and of *Cauac* in the Codex Troano are examples, and another is that over the figure of *Kukulcan*, or *Ikilcab*, the so-called long-nosed god, of whom representations appear so frequently in the different Maya codices.

The figures of gods, with their head-dresses and the objects represented by the Maya scribes in the Codex Troano and other manuscripts, may be composed of a series of hieroglyphic elements suggesting the names of gods and their attributes or of some of the various characters which they impersonate. An example of this is the head-dress of the long-nosed god of the Codex Troano, which reads *Ikilcab*, while his girdle expresses by phonetic elements the name *Kukuitz*, who seems also to have been *Kukulcan*, *Ikilcab* or *Cauac*, and *Itzamna*. It is not improbable that *Kukuitz*, *Kukulcan*, *Ikilcab*, and *Itzamna* is the *Hunakbu*, or one God spoken of in the Codex Troano and referred to on the hieratic tablets, Casa No. 2, Palenque.

I notice that in the photographs of the ancient cities of Yucatan and other portions of Central America, that which we have hitherto considered as *architectural ornamentation* of *Maya design* is *ikonomatic decoration*, and a notable instance is the name *Chi-chen-itza* on the palaces of that ancient city, which are repeatedly recalled by *Chi* and *itza*, and less frequently by repetitions of the word *Chen*. I make this assertion subject to further alteration and improvement, as I have not examined the buildings themselves, being obliged to depend upon bad photographs and still worse wood-cuts.

The hieroglyphs and ikonomatic ornamentations of Palenque, *Chi-chen-itza*, Labna, Tikul, Lorillard City, and Copan, judging by photographs taken at these places, seem to be allied to one another, but those of *Uxmal* are more archaic, with the exception of Copan.

The plan I have adopted in my analysis of the various components of a 'glyph, those standing for the sounds of the names of the things represented, is based upon the idea that the Maya script, both hieratic and demotic, is similar to the higher grade of picture-writing suggested by M. Aubin, in his analysis of the name *Itz-co-atl*,—represented by the conventional sign for water, obsidian attachments to the shaft of the arrow, and a vase or pot,—which by reference to his work will more fully appear.

Proceeding upon this plan, I endeavored to analyze Landa's Key, and have found that the Maya scribe simply gave 'glyphs, whether simple or combined together, that carried out Landa's pronunciation of the Spanish alphabet, by means of characters which stood for the sounds of the names of these letters.

The hieroglyph of a tarantula or centipede, figured in the Troano plates — a claw pinching a rope attached to the foot of a deer-like animal, and also a hand attached to the same insect-like figure in the act of pinching — suggested the various curved 'glyphs of the verb *C^{h}i* (Maya, to bite), which are, I believe, in connection with the parrot 'glyph, *Moo*, a part of the primitive elements of the Maya alphabet. From this I have obtained Chá, Chā (or Che), Chi, Cho, Chu, and from the *Moo* (parrot) 'glyph has been obtained a, e, i, o, u. This system has been applied successfully to the rendering of the components of the day-signs of the Troano manuscript and those of the Chilan Balaam of Káua, using Dr. Brinton's plates for the work — those published in his essay upon the books of "Chilan Balaam," pages 16 and 17.

In several cases certain 'glyphs, such as that of *Ikilcab*, *Cauac*, and *Itzamna*, have suggested meanings so clearly expressed that the words were easily found in the vacubulary of the Abbe Brasseur de Bourbourg, and had such a strong resemblance to objects and 'glyphs carried by the figures to which they belonged, that I venture to think the alphabet which I have arranged will eventually work successfully. It is based upon studies of the hieratic script made while at the Ecole de Beaux Arts in 1875–76–77, and work done on the Troano script in 1880; these researches being thrown aside and recommenced since Jan. 1, 1892.

Although Dr. Thomas and myself have proceeded in methods totally different from each other, and have never yet met to make comparisons, in quite a number of cases our methods have shown like results. I have mailed Professor D. G. Brinton, and the first-named gentleman, proof of this similarity of interpretation, and may also add that before I received a copy of Professor Thomas's "Key" I had mailed, and I venture to say both these gentlemen had received, my analysis and arrangement of the Maya signs of orientation, viz., *Chikin*, West; *Lakin*, East; *Schaman*, North; *Nohol*, South. My arrangement of these signs corresponds to that of de Rosny and Thomas. The first sign of orientation on the list was determined by the C^{h}i 'glyph.

I mention the correspondence of my work with that of Professor Thomas to show that this similarity of interpretation, referred to, cannot be the result of mere guess-work.

The aspirates and signs of repetition and the determinatives of the Maya Graphic System are most important, and I give them as Landa expresses it, and also by dotted lines in circles and curves. The phonetic value of the curve in the Maya alphabet is one of its strongest elements. Most of the characters in the key I have arranged are based on it and other natural suggestions of animate and inanimate nature—

such as the parrot eye, the biting mouth, and the mole-like teeth, the curved line of the serpent's body, and the beautiful outlines of the *antennæ* of the bee, also its sting, and last, not least, the graceful leaf of the maize, and other natural forms which are symbols of fertility.

It may be interesting to remark that the phonetic value of the *antennæ* of the bee was suggested by the third 'glyph, *Cauac*, on the *Kukuitz* bas-relief, left-hand side of the Casa No. 3, Palenque. This 'glyph was traced to more demotic forms on plate 25 of the Troano, also plate 24, where it is upheld by the Goddess *Cab*. Near the figure of *Cab* is the same infant-like figure that is to be seen on the so-called tablet of the cross of Palenque. The component characters of the 'glyphs composing this child's body refer to his name as *Ikilcab*, and this same name is expressed on the head-dress and hieroglyphs of the God-with-the-long-nose of the Troano, and other manuscripts, so-called by students to distinguish him. *Ikilcab* and *Cauac*, the *Cuch-haab*, are in some way clearly connected, for the components of the *Cauac* 'glyph of the day-signs of Landa and those of the Chilan Balaam of Kaua are closely connected with those of *Caban*. The *Cauac* 'glyph, if my interpretation be correct, reads *Ikilcab*. The ancient Mayas probably thought of the bee as *Ikil*, the sting, and *Cab*, honey. The 'glyph of the day-sign, *Caban*, refers to that day-sign and *Ikilcab*, and is also the honey sign ("Bee Keeper's Narrative," the Codex Troano). The numeral signs of the Troana, both red and black, seem to have been used at times ikonomatically. The serpent symbol on plate 25, division 1, Troano, is *C'an*, and close to it are numerals giving the suggestion *Hunakbu*, the one God. On the sun symbol of this plate are numerals, which, in connection with the flute 'glyph (*Chul*) projecting above the sun-disk and the hand below pinching the machete, suggest the interpretation "a name," *Chu-kul-ca-can*.

Alliteration and syncapation for the sake of euphony are especially noticeable in the Maya language, but do not seem to be followed in the arrangement of their graphic characters, and no regularity of procedure, in reading the component parts of a 'glyph, seems to exist. As a general thing, however, some object carried in the hand of a figure, or placed near it, serves as a sort of a determination or suggestion; this is more frequently the case in the demotic than hieratic script.

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N. D. C. HODGES,

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